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Albuquerque, New Mexico.
August 8, 1936.

MEMORANDUM

on

Inoculation Studies, Effectiveness of 1935 Eradication Work and Matsucoccus Scale.

For Regional Forester.

This memorandum is divided into 3 general divisions.

(1) The results obtained by field inoculations.

(2) Effectiveness of the 1935 eradication work in controlling the twig blight.

(3) Data and discussion of the Matsucoccus scale in relation to the Prescott twig blight.

A definition of what constitutes the Prescott twig blight is here given so that all will know what is meant when this subject is under discussion.

Characteristics of the Prescott twig blight.

(1) The killing lesion always occurs at the lower end of the normal needle shed zone for that year, hence after the needles are shed the lesion is usually below any remaining living needles.

(2) The infection enters at the needle shed zone area through needle traces of shed needles, usually in late September or in October and then grows during the winter months until both bark and wood may be girdled.

(3) The killing is caused by hyphae clogging the water conducting system in the wood, thereby causing a definite resining at that place.

(4) In early spring the girdled twigs die suddenly and make what is called flags.

(5) This flagging continues during late March, April and May and ceases when the tree growth becomes pronounced. A few belated flags may occur in June.

(6) After the season's flagging ceases no more flags occur until the next spring.

(7) To produce flagging there must be a multiple infection around the entire stem, top, sides and bottom, since the fungus does not travel very rapidly tangentially in the wood. Lesions found on only 1 side of the twig do not produce flags.

(8) All lesions which do not girdle and kill the twig during the season's flagging cease to grow, due to the rising sap.

(9) Such lesions begin to heal over at the margins by the formation of wound callus and are finally completely covered by healthy bark and wood.

(10) The disease is strictly an annual, since no evidence is at hand showing that a lesion can live 2 seasons or more, neither are any flags found during summer and fall.

(11) The killing lesion of true twig blight is always in the lower portion of the internodes where the needle shed occurs and hence away from the node.

(12) Lesions or killings which occur at nodes are not caused by true blight but by some other agency.

(13) Typical twig blight always kills the entire needle bearing portion of the twig, due to its position on the needle shed zone at the lower limit of the needles on that individual twig.

(14) True twig blight lesions are never found in the first 2 or youngest internodes, since normal needle shed does not occur there.

(15) Rarely are resin lesions found at the nodes and still rarer does any killing occur at the node. However, when such lesions are found they are attributed to the action of a woolly aphis - Adelges on authority of Dr. Blackman. This Adelges is very common and widely distributed in ponderosa pine stands in the spring of the year and is known to feed at the nodes of the current year's growth.

(16) No killing lesions have ever been found on any internode below that season's needle shed zone. That is, none occur on the older internodes of the twig.

(17) The final and conclusive test for the twig blight is the recovery of the "white killer" from the lesion. This fungus has never been obtained from any nodal lesions.

(18) This disease has only been found on Ponderosa pine.

INOCULATION STUDIES

The following is intended to cover the more pertinent data obtained in field inoculations up to June 30, 1936. Many different kinds of inocula were used; also a variety of inoculation wounds were tried and various types of wrapping the wounds were used. Every tree had rather complete data recorded on each twig inoculated. The inoculation wounds used were as follows: "Full girdle", "Half girdle", and "four fifths girdle", are self explanatory. The strips of bark remain attached on the upper end of the girdle and the inoculum is placed beneath these strips of bark in direct contact with the exposed wood and the strips of bark are then put back in place over the inoculum. "Spiral girdle" is an incision of corkscrew type but no bark was removed. "Bark wounds" include a shallow scraping of the outer surface of the bark or simply a small flap cut. "One to three slits" are diagonal slits cut through the bark between the needle bases. "Laceration wound" was one made with pliers, in which the bark was crushed with some slipping at the cambium. "Two to three sides" as applied to inoculation wounds means where a small flap of bark was opened on two or three sides of the twig and the inoculum placed under these flaps. In the line listed "Needles killed by blow torch" a special form of wound was made as follows: Needles on internode was pressed down to twig, and twig wrapped with one inch thick layer of wet cotton. This cotton was pressed tightly and covered completely with copper sheeting. A blow torch was applied evenly to this copper sheeting until steam appeared from the ends of the sheeting. The copper sheeting was then allowed to cool and all wrappings removed. Needles thus injured were poulticed and then inoculated some 8 or 10 days after the steaming, at which time they were browning quite noticeably. This poultice covered all of the browning needles and was held in place by certain types of wrapping.

Table 1

INOCULATION DATA

WOUNDS	WHITE KILLER				WHITE KILLER MIXTURE				NATURAL MEDIA				OTHER FUNGI				TOTALS			
	Inoculated		Checks		Inoculated		checks		Inoculated		checks		Inoculated		checks		Inoculated		Checks	
	made	flag	made	flag	made	flag	made	flag	made	flag	made	flag	made	flag	made	flag	made	flag	made	flag
Full girdle	140	87	61	12	70	51	23	10	23	13	24	3	72	15	36	5	305	166	144	30
4/5 girdle	40	20	10	0	8	5	5	0	6	4	5	0	4	0	5	0	58	29	25	0
1/2 girdle	77	21	36	1	26	10	8	0	41	1	23	0	122	0	42	0	266	32	109	1
Incix 2-3 sides	40	16	13	0	3	1	4	0	8	0	12	0	81	0	34	0	132	17	63	0
Bark maceration	58	20	14	0	5	4	3	0	3	1	5	0	60	0	12	0	126	25	34	0
Bark slits 3 sides	15	3	13	0	6	0	2	0	5	0	-	-	99	0	23	0	125	3	38	0
Bark slits 1 side	5	0											20	0	10	0	25	0	10	0
Bark slits Spiral to W					3	1	2	0					5	0	1	0	8	1	3	0
Bark slits all around	20	11	5	0													** 20	11	5	0
Needle kill blow torch	5	4	3	0	5	3	10	0					15	0	5	0	25	7	18	0
	400	182	155	13	126	75	57	10	88	19	69	3	478	15	168	5	1090	291	449	31

The table headed "Inoculation Data" gives in condensed form the significant results obtained from field inoculations with various types of inoculating media. For convenience and brevity the different classes of inocula used were classified under four general heads as follows: "White killer" means the organism which has been found to produce flagging. "White killer mixture" represents a mixture of several organisms in which the "white killer" is either known to be present or is supposed to be there from general appearance of the mixture. From the very nature of this medium it is evident that some of the cultures used may not have had any of the "white killer" in them. "Natural Media" represents inoculations made with ground-up wood and bark lesions of twig blight. Some of these ground-up lesions were incipient ones while others were made of bark and wood from the killed twig. Under "Other Fungi" is listed various cultures which apparently did not contain any of the "white killer". Such as fast black growing cultures; Conangium Sp cultures; Conangium abietis cultures and cultures showing brown, grey and other colors which contained unknown organisms.

The headings of Table 1. are self explanatory, except two columns, one marked "Made" and the other "Flag". Under the "Made" column is recorded the number of twigs inoculated with the given inoculum and given wound. Under "Flag" is recorded the number of twigs which showed various stages of the flagging process. With these explanations the reader can understand the records as given in this table.

Inoculations made with the full girdle and four-fifths girdle method should produce more flags in proportion to the twigs inoculated than any of the other methods, due to the fact that the inoculum has access immediately to the wood all around the twig except a small area in the four-fifths girdle method. Not as many flags from the half girdle method should be expected as from the two mentioned above since it is well known that this twig blight disease spreads very slowly in a tangential direction in the wood, and the wood must be clogged with the hyphae and resin to stop the flow of the sap before the twig will flag. The bark maceration method is very erratic and results obtained by this method vary as to percentage of flags formed. This is due to the fact that it is hard to tell in the bark maceration process how much of the bark is injured in such a manner that the fungous hyphae can enter. Where the injury occurs on two to three sides of the twig a higher percentage of flags occurs than when the wounding is less. Under the bark slits and the two to three side wounds an appreciable number of flags are formed. These two methods of inoculations were not used until late in the season and hence the number of flags in proportion to the twigs inoculated are smaller than in some of the other inoculation methods used. It is interesting to note that when the"natural media" was used, that is, ground-up lesions of the twig blight, that nineteen flags were obtained from such inocula counting all of the different types of inoculations used. A rather high percentage of flags were also obtained with the "white killer mixture" while the percentage of flags obtained when the inocula used was under the heading "Other fungi" was very small. Of course, it is possible that some of the cultures used under this heading contained the "white killer" and under such circumstances the flagging would be due to the killer, rather than to any mechanical injury from the full girdle used.

It is interesting to note that no flags were produced under "Other fungi" after leaving the full girdle wounds, neither do the checks for the other types of wounds.

It was very difficult to keep the inoculations damp for several days, due to this very dry climate. A proper amount of moisture was necessary so that the fungus used as inocula could get a foothold in the twigs. Inoculations made during the colder months were troubled by the wet cotton wrapped around the inoculated area freezing into a ball of ice which remains in this condition for several days. Both the drying in the summer and the freezing in the winter would naturally lower the number of infections obtained as compared to normal expectations.

The column marked "needles killed, blowtorch" is very significant. Under this method of inoculation seven twigs flagging while none of the checks flagged. In this case the fungus penetrated the bark and from there into the wood without any external wounds. The fungus entered through the bases of the killed needles and spread throughout the bark and into the wood by first attacking the needle traces in the wood. Cultures made from several of these flagging twigs gave one hundred percent recovery of the "white killer". The bark and the wood had all of the characteristic symptoms of the twig blight found in nature. The bark was heavily resined, the resin moved from the bark into the wood through the needle traces and the wood was resined, exactly as in the natural twig blight.

A study of this table (1) will show that flags were obtained under all of the different methods of wound inoculations except where there was only a bark slit on one side. In other words, typical flagging was produced by artificial inoculations in healthy living twigs by the use of the "white killer" which is a fungus obtained either from incipient lesions or from killing lesions on the flags. Flags were produced also by the use of ground-up lesions and by using various types of wounds and finally through the uninjured bark by the fungus entering the bases of artificially killed needles.

In every instance we recovered the "white killer" from the flags where the inoculum used was the "white killer". When a mixture containing the "white killer" was used, this killer was recovered. Where a twig was killed from using a "white killer" mixture it is hard to recover the "white killer" from the flag. This is very pronounced if the flag remains on the tree for any length of time after the twig is killed. In many instances no "white killer" is recovered from the bark and from the outer layers of the resined wood, but will be found in the pith under the killing lesion. Often the "white killer" is recovered from the pith in the internodes above the internode inoculated, while the outer layers of wood and bark next to this infected pith do not give the "killer". In other words, the "white killer" often moves up the pith of the killed twigs, even to the end of the twig before it goes through the wood outward and into the bark.

Table 2

INOCULATIONS MADE FROM OCTOBER 15, 1936 TO JANUARY 30,1937.

Wounds	Inoculations made	Inoculations flags	Checks made	Checks flags
Full girdle	152	102	73	12
4/5 girdle	48	28	25	0
1/2 girdle	76	28	39	1
2-3 sides	20	8	8	0
Bark Maceration	38	20	23	0
Bark slits all around	5	4	5	0
Bark slits 3 sides	5	1	5	0
TOTALS	344	191	176	13

	First flag	last flag
October inoculations which flagged did so between following dates	3-13-36	5-29-36
November inoculations which flagged did so between the following	3-18-36	6-15-36
December " " " " " " "	3-20-36	6-23-36
January " " " " " " "	4-11-36	6-13-36
February " " " " " " "	5-18-36	5-28-36
March " " " " " " "	None	None
April " " " " " " "	none	none
May " " " " " " "	none	none
June " " " " " " "	none	none

Table 3

RECONNAISSANCE CHECK-UP ON EFFECTIVENESS OF 1935 ERADICATION ON NEW 1936 BLIGHT.

Areas	Chains	Acres	Trees checked	Trees blighted prior years	Trees blighted 1936	New trees	No flags 1936	Av. flags per inf. tree 1936	% of trees infected prior yrs	% of trees infected 1936
Lynx Creek	129	6.45	2259	669	14	1	19	1.4	29.6	.006
Maverick Mt	71	3.55	3501	502	14	3	14	1.0	14.3	.004
Little Walnut	27	1.35	207	134	9	0	12	1.3	50.2	4.3
Lite Ranch	20	1.0	331	174	3	0	6	2	52.6	.90

RECONNAISSANCE FOR AMOUNT OF BLIGHT ON UNPRUNED AREA 1936

Lynx Creek	77	3.85	1002	391	332	51	1418	3.7	39.0	38.1

The following areas were so free of blight due pruning operations that they were omitted from eradication work this yr.

Area No. 1 ; All areas west of Copper Basin and Quartz Mountain. No. acres. ——2541

Area No. 2 ; The Maverick Mountain area south of the Wolf Creek Road. " " . ——2618

Area No. 3 ; All of the southeast portion of the Prescott area east of Camp Richard-Big Pine Mine Road, east of the Senator Highway from Groom Creek Ranger Station and south from a line drawn from the Groom Creek Ranger Station northeastward to center of Sec. 24 ——3398;

Area No. 4 ; The area south of an east-west line through the Sheldon Mine in Lynx Creek. ——1062;

Total ——9619;

All of the above areas were cleaned 2 or 3 times. The above records speak for themselves as to the value of the eradication work which is being done to control the Twig Blight.

Table 2. Shows the late fall and early winter inoculations and the flags obtained from these cold weather cultures. Out of 344 winter inoculations - 191 - produced flags, thus proving that the twig blight fungus does grow during the cold weather and is able to kill the twig exactly like it does in nature. The lower part of the table gives the limiting dates for these flags. Notice that after February no inoculations have produced flags. The reason is apparently due to the fact that the rising sap in the twig restrain and finally inhibits the growth of the fungus exactly like what takes place in nature. Even the most skeptical will have to admit that these inoculations have proven a killing organism and that this "killer" parallels in every detail the character and progress of the twig blight in nature. In other words, these data prove that the Prescott twig blight is caused by a fungus.

Effectiveness of the 1935 Eradication Work

Table 3 - shows the results obtained from the 1935 eradication work. The Prescott areas, as a whole, show exceedingly satisfactory results. The Lynx Creek and Maverick Mt. areas show only a few 1936 flags, while the Lynx Creek area which was not pruned shows a large number of 1936 flags. The cleaned Lynx Creek area shows only 6 trees to the thousand with flags and only 1.4 flags per infected tree, while the uncleaned Lynx Creek area has 381 trees to the thousand, or 63.5 times more than the cleaned area besides averaging 3.7 flags per infected tree.

The success of the eradicationwork is also shown by the 9619 acres so free of blight that they were omitted from eradication work. This area is practically half of the Prescott area covered by the 1935 eradication crews. What better proof could one ask, as to the value of the eradications work.

Tables (1) and (2) show the production by artificial inoculations of healthy green twigs, all the typical characteristics of the Prescott twig blight, as found in nature. The fall infections, the winter growth, the flagging in the spring and the ceasing of flagging as the new season's growth of the pine twig progresses; every step found in the natural twig blight has been duplicated many times in the field inoculations. No scale theory can ever explain these facts. Likewise the results of eradication show a great reduction or even blotting out of this twig blight on large areas which have been cleaned. No scale theory can ever explain such results, but the inoculation results do completely explain why the eradication work reduced so effectively twig blight.

Matsucoccus Investigations and Data

When the scale probelm arose early this spring, it was decided to get as much information on the subject as possible. Therefore, investigations along the following lines were instituted.

(1) General distribution of the Prescott scale in Ponderosa pine stands.

(2) The prevalence, concentration, etc. of this scale in the Prescott area.

(3) The life history and habits of the genus, Matsucoccus, from the literature available on the subject.

(4) Contacting the leading expert and authority on this genus for further knowledge and facts.

Distribution.

Mr. A. E. Frazier, one of our Prescott staff, was selected to make a general scouting trip for the presence of the scale in regions removed from any known blight areas. He had worked 5 years on date scale eradication in Arizona before coming to our office and hence knew something about scale in general. Before leaving on his scouting trip he familarized himself with species found on the stems at Prescott. He also visited the University at Tucson for any further information on the scale that might be available. He did not know about the white cottony egg cases when he left on the trip, hence had to depend on the presende of skins shed (exuvia) or the older preadult forms. In most of the areas visited the females had not emerged and laid their eggs and hence this stage could not have been used even if he had known about it. The area listed in the Coconino and Kiabab National Forests were scouted by Sumner, Ellis, Sandberg and Long; either jointly or separately, according to the individual area. Also the Police Canyon area reported by Frazier was re-scouted by Sandberg and Long at which time an abundance of the scale in the egg case stage was found; thus confirming Frazier's previous findings.

The scouts for this scale soon found that it was more abundant on trees in poor condition. That is, trees twisted and bent by stock, suppressed and much shaded trees, or trees growing on poor sites. In the Police Canyon area there were 2 trees badly injured by snow, and in dense shade. These 2 trees were heavily infested with the scale while undamaged trees more in the open had a very light percentage. The heavily infested trees on Baker Butte are those growing in dense overcrowded stands while the Heber-Rim road areas are on very poor sites and the trees are scraggly and poor.

If Frazier and the other scouts could find as many localities with scale by a hurried survey along the roads traveled, how many areas would be found by thoroughly scouting each forest, especially at the time in the year when the white egg cases are present. He only spent 1 and 2 days in each forest and naturally could not check carefully any extensive territory. Mr. Frazier states, "all infestations of Matsucoccus occurred at elevations between 5500 to 7600 ft. Most of the scale found were in deep canyons on southerly slopes."

Table 4 - shows the distribution of the Prescott stem feeding Matsucoccus. This table includes the areas scouted by Frazier as well as those by the other men previously mentioned. The table is self explanatory and further comments are unnecessary.

Table 4

DISTRIBUTION OF THE PRESCOTT STEM FEEDING MATSUCOCCUS

States	National Forests	Areas	Blight present on area	
ARIZONA	Prescott N.F.	1-Prescott & vicinity	Yes	1
	Kiabab N.F.	1-Cape Royal at top	??	2
		2-South of V.T.Ranch	None	3
		3-North of Jacob's Lake	None	4
		4-East of Jacob's Lake	None	5
		5-East of Williams	None	6
		6-West of Williams	None	7
	Coconino N.F.	1-Lower limit Ponderosa pine in Oak Creek	None	8
		2-Upper Oak Creek Canyon	Yes	9
		3-On road from Oak Creek to Flagstaff	None	10
		4-North to Ft. Valley	None	11
		5-West of Flagstaff on road to Williams	None	12
		6-North of Flagstaff on road to Cameron	None	13
		7-Baker Butte	Yes	14
	Sitgreaves	1-Hever & Rim roads junction	Yes	15
NEW MEXICO	Gila N.F.	1-Little Walnut	Yes	16
		2-Mimbres	Yes	17
	Apache N.F.	1-Near Reserve, N.M.	None	18
	Santa Fe N.F.	1-Polica Canyon along 3 mile stretch	None	19
		2-Between La Cueva & Bland	None	20
		3-Vicinity of Pecos & Gallina Canyons	None	21
	Cibola N.F.	1-White House Canyon	None	22
		2-Tajique Canyon	None	23
		3-Between Ft.Wingate & McGaffey Ranger Station in Zuni Mts.	None	24
	Carson N.F.	1-Between Vallecitos & El Rito near Valley Grande Peak	None	25
CALIFORNIA	Reported by Davidson but not seen No real twig blight found on this area		None	26
COLORADO		Monument area-no real twig blight found on this area	The scale on this material was reported by Davidson as M.fasciculensis not a stem feeder.	

Of these 26 known localities for this scale, 6 are in twig blight area, 1 in a suspicious [illegible] and 19 are areas which are free from twig blight.

GENERAL STUDIES AND DATA ON THE PRESCOTT SCALE

Some facts concerning the habits of this scale are here given for the information of the reader.

Life History as far as Known of the Prescott Stem Feeding Scale.

(1) Eggs laid in spring of year in white cottony nests.

(2) Eggs hatch into very small larvae having legs and moving about on the twigs.

(3) Indications point to a second larval stage with legs but this is not proven.

(4) The active larvae finally settle down on the twigs where they stay until they are grown.

(5) These active larvae, after attaching themselves to the younger portions of the twigs lose their legs and become embedded in the bark in a kind of gall.

(6) The apodous or legless stages live in these tiny galls and probably are full grown by October, at which time they cease feeding and xxxx reach the resting or pupal stage (preadult of the entomologist).

(7) They over-winter in this pupal or resting stage.

(8) In spring these pupae change into the imago or full grown adult.

(9) These adults then emerge from the twig galls. They have feet but are wingless.

(10) These females on emerging excrete a white cottony substance as a nest in which to lay their eggs and then die. The dead females remain in this white cottony nest and can be seen as a brownish black dried body. This takes us back to the first or egg stage again.

One can see from this live history that this is a very peculiar scale, the adult females are wingless, as are the young larvae, in fact there are no wings present in this species except the winged males, if there be any. Also, note that this scale is not viviparous, that is, does not bear living young at any stage in its life cycle, hence the number of scale that can develop from 1 female is the number of eggs laid in the spring. This fact limits the number of scale possible on any twig during 1 year to the number of eggs laid at first. The insect is very minute, practically microscopic and hard to see with the naked eye or even with a hand lense in the young stages. Its habit of living embedded in the bark in a tiny gall also makes even the older and advanced stages difficult to find.

There is a very closely related species of this genus M.Matsumurae, found in the eastern United States which feeds on pine stems and is very similar in its general characteristics and life history. The Prescott scale is undoubtedly an undescribed native species and is apparently widely distributed throughout the Ponderosa pine stands in the southwest. (see table 4). Its very minute size, its habit of living embedded in the bark and the fact that it does not produce any serious damage to its host has prevented it from being discovered and described sooner. If the presence of the scale on the pine caused any visible damage then there would be many such damaged areas all over the Ponderosa pine region. The absence of any winged forms other than the males and absence of any viviparous generations prevent this scale from spreading very rapidly from one locality to another. Its spread must therefore be exceedingly slow and it probably took centuries to cover the immense Ponderosa pine stands where it is now common.

The Prescott scale is very difficult to find in any of its stages due to its microscopic size and its habit of living embedded in the bark; except the mature females enclosed in their white egg cases or cottony nests. They are then visible to the naked eye and therefore easily counted since each egg case with its dead scale can be picked out with a pair of forceps. The presence or absence of these cottony egg cases is an easy means of determining the presence of the scale on any given locality, tree or twig. Anybody can see these egg cases with the naked eye and there can be no question or argument in the matter. Early in May is the best time to check these scale in Prescott and other areas of like altitude, say 6000 and 7000 ft; while the latter part of May for areas with higher altitudes will show all the scale have emerged and laid their eggs.

Tables 5 and 6 give much valuable data on the presence and concentration of this scale on the infested twigs for the various areas listed.

Table 5

MATSUCOCCUS DATA

Area	Date col	Twig nos	Tip Scale	Tip Lesion bark	Tip Lesion wood	Node 1 Scale	Node 1 Lesion bark	Node 1 Lesion wood	Node 2 Scale	Node 2 Lesion bark	Node 2 Lesion wood	Node 3 Scale	Node 3 Lesion bark	Node 3 Lesion wood	Node 4 Scale	Node 4 Lesion bark	Node 4 Lesion wood	Av.per twig
Lite Ranch, Gila N.F. from blight free area	5/23	30	165	0	0	133	0	0	24	0	0	10	0	0	0	0	0	11
Av.scale per node			5.5			4.43			.8			.3						
% scale per node			49.7			40.0			7.2			3.0						
Little Walnut, Gila from blight area	5/23	48	238	0	0	162	0	0	34	0	0	0	0	0				9
Av.scale per node			4.95			3.37			.7									
% scale per node			54.89			37.32			7.8			0	0	0	0			
Mimbres, Gila N.F. from blight area	5/24	15	72	0	0	57	0		5	0	0	0	0	0	0			9
Av. per node scale			4.8			3.8			.33									
% scale per node			53.73			42.53			3.7									
TOTALS for the three areas		93	475	0	0	352	0	0	63			10	0	0				
Av.scale per node			5.1			3.78			.67			.1			0			9.67
% scale per node			52.7			39.0			7.0			1.1						
Baker Butte from blight area	5/21	27	228	0	0	207	5	2	37	2	2	0	0	0	0			17.47
Av.scale per node			8.44			7.66			1.37									
% scale per node			48.3			43.85			7.83									
Heber & Rim Road from blight area	5/22	37	1230	0	0	1335	0	0	1665			249	0					
% scale per node			48.53			43.22			7.22			1.0						
Polica Canyon several hundred miles from any blight	5/23	41	270	0	0	257	10	1	38	6	1	7	0	0	0	0	0	13.9
Av.scale per node			6.55			6.28			.92			.17						
% scale per node			47.2			44.9			6.6			1.2						
Total for the three areas		105	928			847			105			16						18.36
Av. scale per node			8.33			8.06			1.32			.15						
% scale per node			48.08			43.88			7.20			.82						

All of the above records were taken from green apparently healthy twigs. All of the trees of the special Lite area from which the twigs came were infested with the scale and practically every branch on each tree had scale and yet no blight was present on this area. The twigs from Baker Butte, Heber-Rim road and from Polica Canyon were the heaviest infested [redacted] that could be found on those areas. This was done to study the injuries, if any, which might be on such twigs. The lesions found are shown in the above table under the proper heading. IN NO INSTANCE WERE ANY LESIONS FOUND [redacted] THER INTERNODES. The few that were present occurred directly on the Nodes.

Table 6

MATSUCOCCUS DATA continued.

AREA	Date collected	Twig nos	Tip Lesion: scale	Tip Lesion: bark	Tip Lesion: wood	Node 1 Lesion: scale	Node 1 Lesion: bark	Node 1 Lesion: wood	Node 2 Lesion: scale	Node 2 Lesion: bark	Node 2 Lesion: wood	Node 3 Lesion: scale	Node 3 Lesion: bark	Node 3 Lesion: wood	Node 4 Lesion: scale	Node 4 Lesion: bark	Node 4 Lesion: wood	Av per twig
Lynx Creek	4-29																	
	5-4	2683	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Green twigs		2528	4442			3138			1150			139			0			
Av. scale per node			1.75			1.24			.45			.05			0			3.5
% scale per node			50.08			35.38			12.96			1.57			0			
Lynx Creek	4-29																	
Flagged twigs	5-4	465	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		281	386			261			86			3			0			
Av. scale per node			1.37			0.92			0.3			0.01			0			2.6
% scale per node			52.44			35.46			11.68			0.40			0			
Oak Creek Rim																		
blight free area	4-30	207	281			197			72			8			0			
Av. scale per node			1.35			0.95			0.14			0.038			0			2.7
% scale per node			50.35			35.3			12.9			1.43			0			
Totals for these																		
three areas		3024	5109			3596			1308			150			0			
Av scale per node			1.68			1.18			0.43			0.05			0			3.36
% scale per node			50.27			35.38			12.87			1.47			0			

Of the flagged twigs there were 465 or 62% with no scale, 168 twigs or 68% with only 1-3 scale per twig and only 1 flag had 14 scales, the maximum found on the blighted twigs. In other words, the scale infestation on the blight killed twigs was exceedingly light, with an average for all the flags of only 2.8 scales per twig. The trees without blight from the same Lynx Creek area showed - 1428 twigs or 50% with no scale, while 25 twigs had 14 scale each and only 9 had 15 scale each, the highest found on any twig. Now even in the healthy trees the scale was very light having an average of 3.72 scale per twig. In fact there is nothing in the Prescott area to indicate that there has ever been a very heavy infestation of this scale there. All of the data shown for Prescott was taken from Lynx Creek and from areas where the twig blight was the heaviest. Therefore, if there is any connection between the scale and twig blight it would show on this area. All of which certainly does not indicate that the scale was the cause of the blight.

The concentration of the scale at the upper and youngest portion of the twig, that is, the tip and first node - as shown in table 5 - is not due to the females crawling up the twig to that point. The presence of the old skins of the preadults at the tip and at the first node show that the females did not move far but proceeded to lay their eggs on the site from which they emerged. If the adults emerged from the lower and old internodes then it is strange how they happened to divide so evenly between the tip and 1st node. If they were trying to crawl to the tip then most of them should be found at the tip, which is not the case. It would hardly suffice to claim that the scale which are found at the 1st node become leg weary and exhausted, hence their stopping before reaching the tip. A glance at the records for the various areas as shown in the table, show entirely too much uniformity of numbers at each node for any other explanation of their presence than that each node represents the scale that emerged from or near that node. Notice the sudden drop in numbers of scale at the lower nodes after you leave node 1. Node 2 shows a few scale, while node 3 practically no scale, and node 4 none whatever. In other words this scale prefers the youngest and most rapidly growing portion of the twig, while very few occur on the older, slower growing and tougher bark. In other words, all the evidence points to the fact that this scale does not settle on the old tough lower internodes but rather they go up to the youngest growth that they can find during their crawling stage. This harmonizes fully with their needs in the case, as well as their position on the stems.

One of the Entomologists, while at Prescott, called attention to the fact that a few dead immature young scale could sometimes be found on the underside of a blight killed twig among the needles still hanging on at killing lesion. The same condition may be seen on the living green twigs infested with this scale. Since these scale reach their pupal stage in September or October long before the blighted twigs are killed the death of these young immature scales cannot be attributed to the blight. In fact, the infection of the twig occurs after these young scales have died, furthermore, such infected twigs do not show any signs of death; but stay green until spring. That the dying of the flags do not interfere with the scale which may be present is shown by the fact that the preadult scales on these twigs survive, emerge and lay their eggs just like they do on the healthy green twigs. In other words, the scale during the winter months are in the resting or pupal stage, hence do not feed and as the twig stays green until about the time for the adults to emerge, they can and do come forth and lay their eggs.

Table 7

COMPARISON OF BLIGHTED AND UNBLIGHTED TREES AS TO SCALE

AREA	Date	tree	Twig	No Flag	Flags without scale	Flags with scale	Nos scale	av Per twig	Twigs not blighted	Without scale	With scale	Nos scale	Av per twig
Lynx Creek													
Trees with blight	4-29 5-4	43	5104	746	465	281	736	2.6	2358	1255	1103	3794	3.44
Percent				24.67	62.33	37.67				53.22	46.77		
Trees without blight	"	41	2838	0					2838	1428	1410	5254	3.72
Percent											50.3	49.7	

Twigs with blight lesions

				No.	without scale	with scale							
Oak Creek Rim	4-30	15	295	115	104	11			180	171	9		
Percent				38.3	90.43	9.56				95	5		

Of 295 green twigs checked from this Oak Creek area 115 had blight lesions on them. Of these blighted twigs 104 or 90% were free of scale. On the Lynx Creek area the trees with blight show a somewhat smaller number of scale per twig than the blight free trees. This certainly does not indicate any preference of the blight for the trees with scale. All of the Lynx Creek material came from the heaviest blight infected areas we could find, so as to get any possible connection, if any, between the scale and the blight.

These scale feed on the first two internodes of the current year and then mainly on the nodal areas - not on the internodes or lower portion of the internode. Surely if the host is injured it would be at those places where the scale congregated and yet one never finds any real twig blight, either flags or incipient lesions on the first 2 internodes; neither do the true twig blight lesions occur at the nodes of the older internodes, but always at the lower limit of needles on the internode in question. If one claims that it takes 1 to 5 years for the supposed injuries produced by the scale to appear then surely said injuries would still be at the points where the scale were feeding, that is, at the nodes, and not far below on the lower part of the internode.

COMMENTS on MEMO entitled "ENTOMOLOGICAL ASPECTS of the PINE TWIG BLIGHT".

Page 1 - paragraph 2 of this Memo. A woolly aphis - Adelges - was present on the current season's growth for that year, especially evident at the nodes and Dr. Blackman so identified the white cottony masses found at such points. Remnants of the old egg sacs of the Matsucoccus may also have been present to a slight degree at that late date in the season. Dr. Blackman also stated that the Adelges were able to kill young shoots and that the occasional nodal lesion and the still rarer killing of the 1 or 2 year old tips of a branch could easily be due to Adelges.

Page 2 - paragraph 4 - From this paragraph the reader would think that the areas cited were examples of twig blight caused by the Prescott scale and yet not one of the areas cited was caused by this Prescott species. The California 1918 area was caused by a needle feeder - Matsucoccus fasciculensis. The Silver City material was caused by another needle feeder M acalyptus and was so identified by Dr. Morrison. (See letter dated May 14, 1924). Not only was this a needle feeder but it was not even a Pinus ponderosa but was on pinon. The Nevada material, if I remember correctly, was on pinon and the scale was M. acalyptus a needle feeder. The scale on the Monument material, according to a letter from Davidson, was identified by Dr. Morrison as M. fasciculensis, a needle feeder; while the Long Island, and Pennsylvania material was M. matsumurae. Not only were these various areas not caused by the Prescott scale, but the damage done was not comparable since all, except the eastern material, was due to needle feeders which of course did not produce stem lesions since the insects were not on the stems.

An examination has just been made of a recent collection of pitch pine (eastern material) infested with Matsucoccus matsumurae. There were 21 dead twigs; 19 of these were terminals or 1 yr old and all very small 1½ - 2 mm at base. Only 2 twigs had been killed back beyond the tip and this only for the last 2 year's growth. One of these killed twigs was 3 mm and the other 4 mm in diameter. The tips of on some of the small 1 to 2 year old side twigs were killed. When this killing of the tips continues for several years the entire twig would starve to death for lack of green foliage, and of course finally die. The small size 1½ to 4 mm of the infested twigs make them easier killed than if the scale were feeding on larger branches. There is no real resemblance to the Prescott twig blight in the material seen.

This is evident when you compare the above data with the characteristics (see page 1) of the Prescott twig blight. Not a single one of the 21 killed twigs were killed by girdling, no signs of pitch area much less pitch girdles were present in the wood of the killed twigs. Some observers state that occasional twigs show some resining but the writer has not seen any.

Page 2 - last paragraph - For characteristics of true twig blight (see Page 1) of this memo. True twig blight lesions are not limited to the underside of the twigs where the Matsucoccus larvae are found but are found on top, bottom and sides of the twigs. The statement, "any mechanical wound or injury to small areas of the phloem may produce a pitch girdling of the twigs, often resulting in the death of the twig one to five years later" is not true as far as Ponderosa pine is concerned. Our field inoculations which have extended over more than 2 years clearly show that small mechanical injuries, in themselves, do not persist and grow for 1 to 5 years and such injuries never increase in size to point of girdling but are limited to the size of the original wound. Furthermore, such wounds begin to heal immediately and are soon completely covered by new bark and wood. The writer does not know of any mechanical type of wound so subtle that evidence of the wound does not appear at time of injury but waits 1 to 5 years before becoming evident. Neither does he know any wounding of tissue at one point on a twig being transferred to another and distant point even after 1 to 5 years from date of wounding. Such things do not agree with the general rules of plant physiology and growth.

Page 3 - paragraph 2 & 3 - The writer states that "the known habits of these scales indicate that the migrating larvae move down the twigs to the older needles (2,3 or 4 years) and there feed until mature." Now what are the "known habits" of these scales as given in publications on this genus? In the Proceedings of the Entomological Society of Washington, Vol. 23, No. 1 - January, 1921, is an article entitled, "The Genus Matsucoccus with a new Species" by Dr. Frank B. Herbert, the leading authority on these scale, in which they are discussed and their "known habits" given.

Quoting from page 19 of this paper concerning the habits of a species - M. Matsumurae (so similar to the Prescott scale that Dr. Morrison of the Bureau of Entomology, at first identified it as M. Matsumurae.) Dr. Herbert says, "The only live forms found in the twigs collected in New York in October, 1919 were apodous larvae, some of them containing immature female adults. These were found in the most recent season's growth." Note the statement, "These were found in the most recent season's growth," which would be at the top of the twig, on the youngest growth and not at the bottom on the older wood. In other words, the larvae moved up not down, just the opposite to what the writer of the memo stated. In the next paragraph of this article Dr. Herbert gives the reason for this upward migration as follows: "There is probably but one generation per year, the larvae hatching in the spring and settling on the growing twigs, where they soon molt to apodous larvae. It is quite astonishing that they are able to form galls in the twigs. It is apparently done simply by the bark growing around and over the insect until it is finally covered in much the same way that a scar is covered up. For this

reason it is necessary that they settle on the very young growing shoots." Note that if the larvae are to survive they must "settle on the very young shoots." Such are some of the "known habits" of the scale and show that the scales really go up and not down.

So much for the "known habits" now as to what "present observations" of others who have examined and studied this scale show. In a recent letter Dr. Herbert makes the following statements. "Personally, I can see no connection between the Matsucoccus and the blight. I find the young scale have settled up and down the current season's growth, but have congregated mostly at the outer end of the growth. We find the cast off skins of the first and second stage scales mostly in the same location as where you now find the adult females, indicating that these adults do not move, in most cases, from the point where they emerge." This was written after Dr. Herbert had examined a large amount of material, collected from various localities in Arizona and New Mexico, and showing several stages of the scale, especially the preadults, adults and egg sacs.

Now please note where Dr. Herbert finds that the young scale have settled, on the "current season's growth". These young moved up not down. Note again that they "congregated mostly at the outer end of the growth." That is, at the tip and first node and again the larvae moved up not down. Again Dr. Herbert states, "that these adults do not move in most cases from the point where they emerge." That is, where the adults and egg sacs are now found (as the adults are in these sacs) on the stem and on the stem is where they feed during life and hence there is where any injuries produced by the scale should occur. The tables given show that the scale did exactly what Dr. Herbert stated, congregated and laid their eggs at the tips and 1st nodes of the branches. Our own investigations show the same facts as those stated by Dr. Herbert. In other words, the young scale normally settle on the youngest and tenderest portions of the twigs which would be the current year's growth and the internode below it. This table 5 shows is true for every area listed. 85 % to 92% of the scale is found concentrated at the top and bottom of the current season's growth. The reason for selecting such a feeding place is clearly stated in the quotation made from the published article.

Page 4 - last paragraph - Again the statement about the larvae moving backward "to the oldest needles, usually the 3rd internode", and yet all the "known habits" as well as recent observations show that just the opposite is true. They go up and not down. The tables giving the percentage of larvae on each node show that very few larvae are on the 3rd node; again confirming the date given by Dr. herbert and our own workers.

Page 4 paragraph 3 - No. 1 - One of these heavily infested young trees was seen and the following noted concerning same: The young pine examined had a basket packed full of egg sacs to each internode or years growth of the twig and each internode had a cotton band around it to prevent the young scale from moving to any other internode, thereby, limiting the young larvae to that individual area.

From 4 to 6 internodes were thus banded and each had its own basket of eggs. From the size of each basket and the way the egg cases were packed in them a hundred egg sacs could be a fair estimate of number in each basket. By actual count of egg sacs on other trees it was found that each egg case or nest contained from 30 to 60 eggs, a fair average would be 40 eggs per case. This would make some 4000 young larvae (when eggs hatched) to each internode or 16000 to 24000 larvae to each twig. Some infestation! and far beyond anything found in nature. Just what was expected from this experiment is not evident. The bands of cotton at each node prevent any migration of the larvae beyond that internode and hence nothing could be learned as to where these larvae would go and settle on the twig if left free as in nature. Neither would the effects produced by the scale tell anything as to their possible relationship, if any, to the twig blight since there were many thousands of larvae per twig in the experiment, while actual counts of both flagged and healthy twigs even on the worst twig blight, areas at Prescott show only two or three scale per twig and not some 16000 or 24000 per twig. If something does not happen to these experimental twigs it will not be due to any lack of scale on them.

Data for the Lynx Creek twig blight area show the highest number of scale found on a twig was fifteen, with an average of 3.5 per twig. Experiments intended to show what connection, if any, the scale has to twig blight should have had twigs with only 1,2,3,4, etc., sacs per twig up to 15 per twig. The results obtained would then have been comparable to what is actually found in the twig blight area.

W. H. Long.
Senior Pathologist.